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JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

DUST-PREVENTION TREATMENT OF SOLID FUELS

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INFORMATION CIRCULAR

DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

DUST-PREVENTION TREATMENT OF SOLID FUELS[1/]

By L. D. Schmidt[2/]

The number of inquiries received by the Bureau of Mines concerning dust-revention treatment of coal and coke indicates an active public interest in is subject. This circular is intended primarily to be of service in answer-g such inquiries in a general way. The material presented here is based en-irely upon publications by others and on communications to the writer.

The preparation of coal and coke for market is receiving more and more ttention in this country, especially in the domestic fuel market, which is sub-ect to intense competition with oil and gas. Heretofore such preparation has onsisted mainly in preparing sizes best fitted for the intended use of the el and in decreasing the ash and sulphur content. A growing tendency on the rt of the general public to regard basements and cellars as inhabitable parts f the house, which should therefore be kept as clean as possible, has created new requirement for furnace and fuel, namely, cleanliness. This demand for cleaner fuel is augmented by canvassers for oil- and gas-heating equipment.

These new conditions add impetus to the search for methods to keep dust om rising during the delivery of solid fuel or its subsequent handling. The emand for dustless deliveries is not restricted to the domestic field but ex-ends to plants where dust of any kind is especially troublesome, such as akeries, laundries, food factories, hospitals, and hotels.

Several ways of meeting this dust problem are: (1) Use of tight bins, utes that lower the fuel carefully on delivery, and direct mechanical stoking nto the furnace; (2) treatment of the fuel to render it dustless; (3) delivery n packages small enough to be fired directly into the furnace.

While a decrease in dustiness is not the primary aim in plants that pre-are sized and washed coal, nevertheless, careful screening, washing, and de-sting of coal could, if carried far enough, remove most of the finer pieces hat tend to form dust when handled. However, this method would give rise to he serious problem of how to dispose of fines profitably, and thus tend to aise the cost of this method of obtaining a dustless fuel. Furthermore, sub-equent handling and shipment would cause additional fines to form, increasing

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the dustiness of the fuel. Some progress in the dedusting of fuels[3] is bei made, and some of the carefully prepared fuels are, without doubt, less dust even though no dustproofing agents have been added.

ADDITION OF DUSTPROOFING AGENTS

The practice of spraying fuels with various liquids to reduce dustiness becoming increasingly popular.[4]

Spraying equipment is being installed at many mines and preparation pla and also in retail coal yards. In a special report to the Federal Housing Administration by L. B. Sisson of Mellon Institute, the results of inspectir about 1,000 retail coal yards indicated that about 10 percent east of the Alleghenies and about 15 percent west of the Alleghenies are equipped to tre fuel with dustproofing agents.

Many substances have been suggested for addition to fuels to decrease d ness. Some of the characteristics an ideal treating agent[5] should have are (1) effectiveness for the period of time desired, (2) low cost per ton of fu effectively treated, (3) no harmful effects on person, clothing, or equipmer (4) lack of odor in the consumer's bin, (5) no danger of flash-back or rapi evolution of obnoxious gases on firing, (6) freedom from the possibility of freezing in spraying equipment, (7) no increase in the tendency for fuels t cake or lump in freezing weather, (8) no deleterious effect on the combusti characteristics of the fuel or on the fusion point of the ash, (9) no delet ous effect on the storing qualities of coal.

The following substances are among those that have been offered for th commercial treatment of solid fuels to render them dustless: (1) water, (2 solutions of hygroscopic salts such as calcium chloride, (3) waste liquor f wood-pulp plants, (4) solutions of blackstrap molasses, (5) water-soluble sulphonic acid compounds from petroleum, (6) oil-in-water emulsions, (7) oi (8) paraffin wax, (9) byproducts of the glycerine industry.

Before discussing these substances in detail we shall consider first t methods of measuring dustiness and the general principles involved in atter to decrease the dustiness of a fuel.

MEASUREMENT OF DUSTINESS

The measured value for the dustiness of a given fuel will depend a gre deal, of course, upon the test method used. Committee D-5, A. S. T. M., o Coal and Coke has a subcommittee on dustiness of coal and coke that is inv gating methods for determining dustiness with a view to developing a stand test procedure.

3/Hebley, H. F., The Dedusting of Coal: Trans. Am. Inst. Min. and Met. En (Coal Div.), vol. 108, 1934, pp. 88-122.

4/Beaman, B. N., Cleanliness Can Beat Competition: The Coal Herald, March p. 11.

5/Bowers, G. F., Coal Spray Oils: The Black Diamond, vol. 95, no. 4, Aug. 1935, p. 17.

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Powell and Russell[6] have developed an apparatus and method that measure .e amount of dust rising when a fuel sample is dropped 4 feet. According to .is method 50 pounds of the fuel to be tested is placed in an upper chamber ' an enclosed cabinet 18 inches square and 5 feet high. By pulling out a .ide the sample is dropped 4 feet. Five seconds later two metal slides are .serted in the dust cabinet just above the fuel. The dust is allowed to .ttle on the top plate for 2 minutes. This plate is then withdrawn and the .st carefully brushed off and weighed. The lower plate is removed at the .d of 10 minutes, and the lighter "float dust" that has settled in the 8- .nute period is brushed off and weighed separately. The results are reported .grams of dust per ton of fuel. This procedure permits the determination of .o kinds of dust - the coarser dust that settles within 2 minutes and the .er or float dust that settles in the period between 2 and 10 minutes. This .e dust is probably the chief offender in use, since it can travel farther .om the source before it settles out of the air.

GENERAL PRINCIPLES OF DUSTPROOFING

Substances added for dustproofing fall into two main classes: those that .rm a liquid film and those that form a solid or semisolid film. The capil- .y forces exerted by a liquid that wets the surface of fuel particles can .tilized to cause the finer particles to cling together or to adhere to .ger particles. This effect may be shown by comparing the properties of a .dful of fine sand when dry with the same sand after it has been wetted with .er. If the liquid film on the fuel particles dries and leaves no agglutinat- g residue the fuel will return to its original state of dustiness. Con- .quently the liquid film must last as long as the fuel is required to be dust- .oof. Both oil and water are liquid-film agents.

If on drying a liquid leaves a solid or semisolid film on the treated fuel, .s residue, if it has agglutinating properties, may give sufficient protec- .on against dusting. Solid or semisolid films also may be applied by raising e temperature of a substance, such as paraffin, until it is liquid and then .plying it to the fuel.

Comparing liquid and solid films, the solid films have, perhaps, in general e advantage of greater permanence, while the liquid films have the property .spreading over any new fines that may be formed by handling or shipping the el after treatment.

The tendency for certain liquid films to creep over new surfaces is illus- .ted by a test[7] in which it is reported that screened coal treated with oil s mixed with an equal amount of untreated coal and the whole put into a re- .ving container for a considerable time. It was found that enough oil had en transferred to the untreated coal so that the whole contained only a small .rcentage of float dust.

6/ Powell, A. R., and Russell, C. C., Method for Determining the Dustiness of Coal and Coke: Ind. and Eng. Chem., Anal. Ed., vol. 5, 1933, pp. 340-341.
7/ Shillie, Sheldon, Dustless Coal: Coal Mining, vol. 12, May 1935, pp. 10-11.

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In addition to preventing dust, these various dustproofing agents are s to improve handling, storing, and combustion properties of solid fuels, especially coal. In general, it is difficult to determine these secondary effects quantitatively, and insufficient experimental work has been published t warrant positive conclusions.

It has been reported that the tendency of fuel to segregate into fine a coarse fractions when handled is decreased appreciably by these agents. Thi is said to reduce handling losses due to accumulation of fines and also to improve handling properties in stoker hoppers,[8/] etc. Claims are made, also that some dust-preventing agents reduce the amount of degradation in size caused by handling.

Little has been published as to the effect of these agents on the weat ing of coal during storage. The effect of the various dustproofing agents the tendency of coal to ignite spontaneously remains to be determined. Som of the other secondary effects of the addition of dustproofing agents will mentioned later, in the discussion of the individual agents.

In discussing the various dustproofing agents commonly used no attempt will be made to indicate that in general one is better than another. The importance to be attached to the various factors discussed depends almost entirely upon local conditions at the place where the fuel is to be treated For example, the fact that water freezes in cold weather does not destroy usefulness as a dustproofing agent in warm weather.

In the following, some of the various substances that can be used are cussed in a general way. For greater detail and descriptions of equipment used to apply these substances the reader should consult the references gi

SUBSTANCES USED IN TREATING SOLID FUELS TO DECREASE DUSTINESS

Water

In treating coal in local yards to render it dustless, water perhaps still the most generally used dustproofing agent. Its low cost and its av ability are in its favor. Its chief disadvantage is that it evaporates a leaves the fuel as dusty as before. However, the practice of wetting the with water or steam at the retailer's yards just prior to delivery in many cases permits dustless deliveries. The water should be distributed evenly throughout the fuel to obviate having to use excessive amounts for effect treatment. The use of an excessive amount of water often causes the cons

8/ Jamieson, D., Jr., Treatment by Oil or Chemical to Improve Quality: Co Mechanization Yearbook, Am. Min. Cong., 1935, pp. 289-293.
Grimes, O. J., Relation of Bituminous Coal Sizes to Performance of Sma Underfeed Stokers: Black Diamond, vol. 96, no. 3, Feb. 1, 1936, p.
Langtry, W. D., Cleaning, Sizing, and Treating: Coal Heat, vol. 28, n September 1935, pp. 8-10.

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complain that the water has been weighed as fuel. Furthermore, if water ips or runs from the fuel the primary object of dustproofing, cleanliness, not achieved. If wet coal is fed into stoker hoppers feed difficulties metimes arise from arching in the hoppers.

With regard to combustion efficiency, an excess of moisture causes loss the heat required to change it into steam and raise its temperature to that the flue gases. Such a loss has been estimated to be equivalent, roughly, decreasing the effective heating value of the fuel by 0.1 percent for ery 1 percent of moisture[9].

In cold weather it is more difficult to use water as a dustproofing agent cause it freezes in pipe lines, etc., and also because the wet fuel itself ll freeze solid and become extremely difficult to handle.

It is impossible to calculate a satisfactory average value for the cost r ton of fuel treated at the local yards, although such a figure would be luable for comparison with costs of other materials used for the same pur- se.

Solutions of Hygroscopic Salts

Some salts, such as calcium chloride or magnesium chloride, will absorb isture when exposed to air at ordinary atmospheric humidities and will ntually dissolve in this absorbed water. When sprayed on fuel, solutions such salts form a nondrying liquid film that stays liquid under normal nospheric conditions. However, if the treated fuel is stored for a long ne under extremely dry conditions (low relative humidity) the liquid film ll dry out and deposit a semisolid film of the salt.

Calcium chloride solution is commonly used for dustproofing fuel. Accord- g to a series of tests reported by J. D. Doherty[10], calcium chloride solu- on was very effective in controlling float dust, that is, the finer particles at require more than 2 minutes to settle in the dustiness-testing apparatus scribed above. Measurements of the ash-fusion temperatures of treated and treated fuels indicated that the addition of calcium chloride tended to de- ease the fusion temperature of the ash when this temperature was high and to crease the fusion temperature when it was low. No appreciable effect of eatment on burning or clinkering properties were observed in standard house- ating furnaces.

One of the chief disadvantages in the use of calcium chloride is its ten- ncy to corrode metal parts with which it comes in contact. This is especi- ly noticeable in metalwork near the sprays and in railroad cars and chutes th which the treated coal comes in contact. In the tests mentioned above, e addition of inhibitors, such as chromates, to the calcium chloride solu- ons appeared to be of doubtful value in preventing corrosion.

Nicholls, P., Flagg, S. B., and Augustine, C. E., Five Hundred Tests of Various Coals in House-Heating Boilers: Bull. 276, Bureau of Mines, 1928, p. 11.

Doherty, J. D., Calcium Chloride Treatment of Coal: Coal Mine Mechanization Yearbook, 1935, pp. 298-303.

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In the vicinity of the calcium chloride sprays difficulties with electr circuits often arise. These circuits must be very well protected from the action of the spray. In general, great care must be taken to minimize the amount of solution deposited elsewhere than on the fuel to be treated.

From 4 to 9 pounds of flake calcium chloride per ton of fuel is reporte to be sufficient for effective treatment. The amount necessary increases w decreasing size of the fuel or with increasing amounts of fines. Flake cal cium chloride in paper-lined bags costs $19.50 per ton f. o. b. producer, o about 1 cent per pound. If it is purchased in solution (40 percent calcium chloride) it costs about $7.50 per ton of solution. Whether flake or solut is to be used depends upon freight charges, facilities for handling, etc.

The total cost of calcium chloride treatment at the mine has been esti mated at from 5 to 12 cents[11/, 12/] per ton of coal.

No quantitative data are available concerning the permanence of the ef fect of treatment or the effect of treatment of coal on its weathering pro ties and tendency to ignite spontaneously.

Other Water-Soluble Substances

Other water-soluble substances have been suggested and tried from time time. The main factor that determines their value for dust prevention is t cost per ton of fuel effectively treated but other factors must be consider such as properties that may be harmful or beneficial in other respects tha dustlessness. Also, since they are water soluble, their permanence under posure to ordinary weather conditions must be considered.

Blackstrap molasses in water solution has been suggested, but no info tion is available as to its cost per ton of fuel effectively treated.

A byproduct of glycerine manufacture containing salt and soda ash has suggested. Its cost for dustproofing purposes is reported to be high.

Petroleum sulphonic acid compounds in water solution have been used, little information as to costs is available.

Waste liquor from cooking wood chips in pulp mills[13/] has been used t considerable extent for decreasing dustiness. Meredith[14/] reports that wa sulphite liquor (22-percent solution) costs about 7 cents per gallon, f. o producer, in tank-car lots, and that about 1.75 gallons of 22-percent solu per ton of coke is required for effective treatment. It dries to a semisc film on the fuel and should give relatively permanent protection against

11/ Downing, R. C., Preparation of Dustless Coke by Emulsified Oil Sprayin Gas-Age Record, vol. 75, 1935, p. 603.

12/ See Jamieson, D., Jr., work cited (footnote 8, p.4.)

13/ Cunningham, Noel, and Peck, C. L. (to Champion Fibre Co.): U. S. Pate 1988999, Jan. 22, 1935. Chem. Abs., vol. 29, 1935, 1970.

14/ Meredith, H. J., Dustproofing Coke: Proc. Am. Gas Assoc., 1934, pp. 9 Gas-Age Record, vol. 73, 1934, p. 533.

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stiness as long as an appreciable amount of new fines is not made by han-
ing. The objection has been made that a disagreeable odor is given off when
el treated in this way is placed on a hot fire. While this might affect the
les appeal of the fuel adversely the matter should not be serious. In fact,
e odor might be an advantage as a warning of leaking flues with their atten-
nt danger. The cost of applying waste sulphite liquor to fuel should not be
gh, and the total cost per ton of fuel treated would depend on the freight
arges from the pulp plant.

Oil

The use of oil for treating fuels to decrease dustiness is growing rapid-
.15/, 16/, 17/, 18/, 19/

Oil is applied to coal or coke by spraying from pressure nozzles as the
al is moving on a conveyor or, preferably, as it tumbles on leaving a con-
yor or chute. Good distribution of the oil in a thin film over the surface
the coal particles is essential.

Although oil itself is combustible and adds to the heating value of the
el, excessive amounts must be avoided.

Numerous oils are offered for this purpose, ranging from crudes to es-
cially compounded oils. According to Van Voorhis20/ a survey of the speci-
ications of several oil companies for the characteristics of the oils that
ey recommended for direct spraying of fuel showed the following range:

Viscosity (Saybolt)	100-225 seconds at 100° F.
Gravity (A.P.I.)	18.5 - 25
Flash point, °F.	305 - 370
Fire point	420° F.
Pour point	-40 to 10° F.
Quantity	Up to 3 quarts per ton.

In addition to these characteristics the oil should not give an objection-
le odor when the coal is stored in the domestic bin, and it should be clean
nd well-filtered so as not to plug the filters or spray nozzles.

In general, the lower-viscosity oils are easier to handle and apply evenly
n the fuel, while the higher-viscosity oils are more permanently effective.
hen oil-treated coal is charged on a hot fire the oil tends to vaporize, and
f an excessive amount of an oil of too low flash point has been used there is
nger of an immediate flash-back upon firing.

See Smillie, Sheldon, work cited (footnote 7, p. 3).
See Jamieson, D., Jr., work cited (footnote 8, p. 4).
Mining and Metallurgy, Coal Oil: Vol. 16, 1935, p. 492.
The Coal Dealer, Claims Patents Covering Oil-Treatment Process are Obsolete: Vol. 31, May 1935, p. 62.
Combustion, Treated Coal v. Performance: Vol. 7, no. 11, 1936, p. 15.
Van Voorhis, M. G., Petroleum Oils Prevent "Coalitosis": Nat. Petrol. News, vol. 27, no. 11, Mar. 13, 1935, pp. 116-118.

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The pour point of the oil indicates the ease with which it can be handl in cold weather.

The quantity of oil necessary to produce a given degree of dustlessnes coal depends upon the size and amount of fines present. The following tabl taken from data published by West[21] and Strunck[22], gives, roughly, the am required for satisfactory dustproofing. The figures given are only approxi- mate, and the amount required depends upon the type of coal treated and the permanence and degree of dustlessness required:

Size of coal, screen openings, inches	Quarts per ton
Through 5/16	4 to 5
3/16 to 3/4	3.5
Through 1	3
Through 1-5/8	2.5
1 to 1-5/8	2
1-5/8 to 3	1.5

Too much oil or uneven distribution of the oil on the fuel defeats the purpose of greater cleanliness because of drainage of oil from the fuel.

Oil can be applied to the fuel cold, hot, or in the form of an emulsio in water. If it is to be applied cold, higher pressures must be used since the viscosity of oil increases rapidly with decreasing temperature. Pumps used for pressures of 300 to 600 pounds per square inch, and oils with vis- cosity ranging from 100 to 200 seconds at 100° F. are handled[23], [24]. If oil-storage tanks are placed underground less heat is required to keep the liquid enough to be handled in cold weather.

In some systems the oil is heated either by electricity or with steam before it is pumped to the spray nozzle[25], [26]. This permits the use of higher-viscosity oils with lower pump pressures and makes control of the sp ing process in cold weather easier.

Oil is often sprayed in the form of an emulsion in water[27], [28]. In way very viscous oils can be applied from low-pressure systems. These emul sions contain from 6 to 7 percent oil. There are available on the market c

21/West, C. E., Dustproofing Coal Brings Wide Consumer Acceptance in Highly petitive Domestic Markets: Coal Age, vol. 41, no. 6, 1936, pp. 229-2
22/Strunck, G. A., The Application of Oil as a Treatment for Dust Eliminati Coal Mine Mechanization Yearbook, 1935, pp. 294-6.
23/See Jamieson, D., Jr., work cited (footnote 8, p. 4).
24/The Brown-Fayro Co. sales literature.
25/The Viking Manufacturing Co. sales literature.
26/Vinz, A. O., Treating Coal with Oil to Suppress Dust: Chem. Abs., vol. 1935, p. 5253. U. S. Patent 2005512, June 18, 1935.
27/See Meredith, H. J., work cited (footnote 14, p. 6).
28/See Downing, R. C., work cited (footnote 11, p. 6).

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at contain their own emulsifying agents.[29] Other oils may be emulsified in ter if emulsifying agents such as sodium resinate are added. In winter these ulsions are subject to freezing, both in the system and after application the fuel.

The cost of oil treatment of fuel has been given at 4 to 20 cents per ton fuel treated[30], [31], [32]. If the fuel is treated at a place where it can done on a large scale the costs, of course, are lower per ton than if it done in a small retail yard. The available information as to permanence dustproofing is insufficient to permit any conclusion as to how long a tisfactory degree of dustlessness will persist after treatment. However, a suitable grade of oil has been applied the treatment should be effective r several months, even though the fuel is exposed to the weather.[33] Fife d Edeburn[34] report that petrolatum (a mixture of oil and amorphous wax) ves more lasting protection against dustiness than do the usual amounts of 0-200 viscosity oils.

With regard to secondary effects, oil serves as a preservative for metal rfaces with which the treated coal comes in contact, such as railroad cars, tail-yard equipment, stokers, etc. If coal is properly treated it is said be handled more easily and to flow more readily over grates, thereby giving more even fire bed and permitting an even ash-pit pressure under the entire el bed[35], [36]. It has been reported that if the proper grade of oil is ed on the coal the rate of oxygen adsorption at storage temperatures is de-eased[37] and there will be less likelihood of spontaneous ignition.[38] rther studies are necessary to determine these effects quantitatively. As gards fires it should be kept in mind that the fine spray produced at the zzles is inflammable. Even though the flash point of the oil is high, as termined by the standard procedure[39], the flash point of the finely vided oil in the spray could be much lower due to the large surface from ich the more volatile ends could vaporize rapidly. If atomization is com-ete enough to give a very fine fog it is possible that an explosive mixture uld be formed. If ignited this explosion might not be serious in itself

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29/ Morris, H. H., Developments in the Oil Treatment of Coal: Presented at the tenth meeting of Fuel Engineers of Appalachian Coals, Inc., Cincinnati, Ohio, Sept. 16, 1935.
30/ See Jaimeson, D., Jr., work cited (footnote 8, p. 4.)
31/ See Smillie, Sheldon, work cited (footnote 7, p. 3.)
32/ See Downing, R. C., work cited (footnote 11, p. 6.)
33/ See West, C. E., work cited (footnote 21, p. 8.)
34/ Fife, H. R., and Edeburn, P. W., Amorphous Paraffin Wax as Protective Coating and Dustproofing Agent for Solid Fuels. Paper presented before 92d meeting, Am. Chem. Soc., Pittsburgh, Pa., September 7-11, 1936.
35/ See Morris, H. H., work cited (footnote 29, page 9.)
36/ See Combustion, work cited (footnote 19, p. 7.)
37/ See Fife, H. R., and Edeburn, P. W., work cited (footnote 34.)
38/ See West, C. E., work cited (footnote 21, p. 8.)
39/ American Society for Testing Materials, Standard Method of Test for Flash and Fire Points by Means of Open Cup: A.S.T.M., Standards, part II, 1933, pp. 800-804.

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but it is possible that it would initiate a self-propogating dust explosion b raising dust deposits that are usually present in preparation plants and near tipples. One possible source of ignition of the spray is a spark due to static electricity.[40] Evidence of this tendency for static charges to be built up in the spraying process has been compiled by Guest.[41] Because of this possibility of sparks, care must be taken that all metal parts near the spray are thoroughly grounded.

Tests[42] have indicated that the oil treatment tends to decrease somewhat[43] the tendency for moist slack to freeze into lumps and onto the sides of cars, etc.

PACKAGED FUEL

Where local conditions permit, slack coal can be packaged[44]. Some bin ing material, such as starch, is added and briquets are made under pressure. The briquets are then wrapped in paper to form packages containing 15 to 30 pounds of coal. These packages can be fired directly into the furnace by ha no shoveling being necessary. It is said that the cost of packaging is abou $2 to $3 per ton. In those places where the disposal of fines is a problem and where the market will support the additional cost, this outlet should be welcome.

40/ Price, A. W., Does Static Electricity Cause Ignition of Wild Wells?: and Met., vol. 17, 1936, pp. 240-242.

41/ Guest, P. G., Static Electricity in Nature and Industry: Bull. 368, B of Mines, 1933, p. 52.

42/ See Morris, H. H., work cited (footnote 29, page 9.)

43/ Gilbertson, H. S., Anthracite Industry Finds Theft its Biggest Problem Production Drops 12 percent: Min. and Met., vol. 17, 1936, p. 41.

44/ Mitten, R. F., Packaged Fuel Proves Profitable: Coal Heat, vol. 29, n 24, April 1936, pp. 18-20.

45/ The Coal Dealer, Packaged Coal Gaining in Popularity in Northwest: Vo 32, no. 12, April 1936, p. 41.

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